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Learning from trade through innovation: Causal link between imports, exports and innovation in Spanish microdata*

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Abstract

The paper explores the learning from trade hypothesis. Standardized research approach searchs for learning effects from trade focusing solely on exports, whereby firm's learning effects are accounted in the form of total factor productivity improvements. In contrast, this papers defines a firm learning from trade in terms of introduction of either new products or processes induced by its import and export links with foreign markets. By using microdata for a large sample of Spanish firms, including data on innovation and trade, we find clear sequencing between imports, exports and innovation. The results suggest that firms learn primarily from import links, which enables them to innovate products and processes and to dress up for starting to export. In a sequence, exporting may enable firms to introduce further innovations. These positive learning effects from trade, however, seem to be limited to small and partially medium firms only. On the other side, firms that are closer to the relevant technological frontier seem to benefit more from trading activities in terms of innovation than the technological laggard firms.

JEL classification: D24, F14, F21

Keywords: firm heterogeneity, innovation, exports, imports, matching

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1 Introduction

Recent literature dealing with the impact of trade on firm performance has found it difficult to provide a convincing mechanism for learning-by-trading, i.e. how firm's foreign trade participation feeds back into their performance. Primarily, this is due to the fact that the literature is predominantly focusing on exporting. Here, the existing theoretical models in the tradition of Melitz (2003) with heterogenous firms and randomly assigned productivities fall short of explaining why some firms are initially "better", enabling them to start exporting. Studies dealing with the impact of imports on firm performance are rather scarce. If at all, then imports are studied primarily as a source of increased competition in the local markets forcing firms to adjust to increased competitive pressures. More recently, Amiti and Konings (2007) study the effects of import liberalization on plant productivity of Indonesian firms both through tougher import competition as well as through access to cheaper intermediate inputs. They show that access to cheaper intermediates might have a 10 times larger impact on firm productivity gains than that of increased import competition. Similarly, Altomonte and Bekes (2008), and Damijan and Kostevc (2010) show superior effects of importing relative to exporting for firm performance.

Yet another reason for failing to find conclusive evidence on firm learning effects from trade may lie in the way these effects have so far been measured. Aw et al. (2005) argue that a number of studies that failed to find evidence of learning-by-exporting may have neglected a potentially important element of the process of productivity change: the investments made by firms to absorb and assimilate knowledge and expertise from foreign contacts. This means that both importing as well as exporting activities may have helped firms to become more innovative in terms of their production processes or products, which may impact productivity growth and/or firm survival in the long run. Hence, one might not expect immediate impact of trade participation on firm productivity growth, but should study the changes a firm is introducing subsequently to trade participation both in terms of the product structure and their characteristics as well as in terms of the organization of its production processes.

In this paper we propose to alter the common approach to studying the effects of learning from trade. Instead of using the total factor productivity as a measure of learning, we study firm learning from trade in terms of introduction of new products or processes following its engagement in either import or export activities. Specifically, we study the sequencing of firm's learning from trade through its engagement in imports, the decision to start product or process innovation, the decision to start exporting and to further product or process innovations induced by exports. We build a simple theoretical setup based on the Melitz (2003), Yeaple (2005) and Bustos (2007) framework, where firms are heterogeneous in terms of productivity assigned exogenously, but have a choice between investing in two different levels of technology (low and high) by paying an additional fixed cost of research and development. Technology upgrading is dependent on research and development expenditure, which serves as a necessary condition for product or process innovations enabling firms to increase markups or improve productivity. The modeling framework is based around a monopolistically competitive sector with differentiated products produced with a single factor of production (labor). All final goods are allowed to re-enter a firm's production as intermediates, which can substantially impact it's marginal cost in the event of international trade. Firms are allowed to trade internationally by paying both fixed exporting and fixed importing costs. By importing intermediates from abroad firms can significantly reduce their marginal and total costs allowing for higher share of expenditures invested into technology upgrading. Both trading and technology upgrading are reinforcing each other through a process of ongoing productivity improvements.

This theoretical setup provides rationale for a specific sequencing of imports, exports and innovation. Firms with extensive importing links are more likely to introduce new products or processes, which will help them to "dress up" in terms of productivity for the upcoming decision to start exporting. Exporting, in turn, further boost additional product and process innovations. All these activities could conceivably translate into ongoing firm productivity gains.

In order to study this sequencing of firm learning effects from international trade links, we make use of the rich panel datasets on Spanish manufacturing firms (ESEE, 1991-1999) combining usual firm-level balance sheet data with the data on innovation and trade flows. We employ matching techniques to explore the exact sequencing between firm's engagement in trade and its learning from trade through innovation. Our results suggest that firms learn significantly from their import activities both in terms of product and process innovations. Engagement in imports and innovation activity are then shown to trigger the decision to start exporting. Exporting in turn may induce further innovations. This sequencing, however, is found to be important predominantly for small and partially for medium-sized firms. On the other hand, firms that are closer to the technological frontier seem to benefit more from trading activities in terms of innovation than the laggard firms. In other words, small and technologically advanced firms are found to learn comparatively more from trade, which is essential for their growth dynamics. These results are important in terms of understanding the impact of trade on firm performance and may find applications in the trade models with heterogeneous firms, which should put more emphasis both on imports as well as on firm's innovation activities.

The paper is outlined as follows. Next Section provides review of the relevant literature. Section 3 presents the data and methodology is explained in Section 4. Section 5 presents the empirical results and the last Section concludes.

2 Literature review

During the last two decades, a vast literature has addressed the issue of firm learning from its cross-border activities. Impact of international knowledge spillovers on firm performance has been studied in their various forms - from outsourcing, over spillovers from FDI to learning-by-exporting. Though extensive, evidence found in the literature does not provide much support in favor of any of these various forms of international knowledge spillovers. While direct technology transfer from parent companies to their affiliates worldwide has been conclusively shown to increase affiliates' performance, no definitive evidence has been found in favor of local firms learning through horizontal spillovers stemming from competition of foreign affiliates in the same industries (Görg and Greenaway, 2004).[1] Similarly, another strain of the literature exploring the learning-by-exporting hypothesis, found quite striking evidence in favor of self-selection of initially more productive firms into exporting rather than learning from their exporting activities (see Greenaway and Kneller (2007) for a survey of empirical studies and Wagner et al (2009) for a consistent cross-country study for 14 countries).

Recent literature falls short of finding a convincing explanation for why some firms are initially "better" and how foreign trade participation feeds back into firm's productivity. Foster et al. (2006) provide some evidence in favor of this by showing that firm-specific demand variations, rather than technical efficiency, are the essential determinants of firm survival, and they positively affect firm productivity. This finding implies that a firm's product innovation due to positive demand shocks may explain a large portion of a firm's higher pre-trade productivity level and its consequent decision to start exporting. A recent study by Cassiman and Golovko (2007) shows for a sample of small and medium-sized Spanish firms that controlling for product innovation causes the differences in productivity among exporting and non-exporting firms to disappear. In a related paper, Cassiman and Martinez-Ros (2007), show that for Spanish firms engaging in product innovation significantly increases the probability to start exporting. Similarly, Becker and Egger (2007) find, after controlling for the endogeneity of innovation, that product innovation in the case of German firms plays an important role in increasing the propensity to export, while they find no such evidence for process innovation. Salomon and Shaver (2005) find some evidence in Spanish microdata that past exporting status increases

[1] Instead, direct upstream and downstream demand - supply links between foreign affiliates and local firms in vertically integrated industries have been found important (Damijan et al, 2003; Smarzynska-Javorcik, 2004).

the propensity of firms to innovate. Damijan et al (2010) extend this evidence by finding that exporting may increase the probability of becoming a process rather than product innovator in a sample of medium sized Slovenian first-time exporters, and that later on exporting may lead to productivity improvements. These findings suggest that product innovations may increase the likelihood of firms starting to export, while participation in trade may positively affect firm efficiency by stimulating process innovations. Damijan et al (2010) hence argue that there must exist a causal link between a firm's innovation effort, its overall productivity level and the decision to start exporting as well as between firm's exporting performance and its further improvements in productivity.

In spite of substantial advances there is still no convincing theory explaining the directionality of the link between firm innovation, participation in trade and productivity improvements. Theoretical models in the tradition of Melitz (2003) lack both a convincing explanation of what generates firm's pre-trade productivity as well as how participation in trade translates into individual firm's productivity improvements. These models assume that firm productivity randomly assigned, but after making the draw, there is no way for a firm to change its life path - its survival or death. Trade liberalization and participation in trade may induce intra-industry reallocations and increase the aggregate productivity, but not the one of the individual firms.

Some recent theoretical work tries to link firm individual ability to innovate and its later decision to start exporting. Bernard et al. (2006) assume firm productivity in a given product to be a combination of firm-level "ability" and firm-product-level "expertise". While they still rely on the assumption that both firm-level "ability" and firm-product-level "expertise" are exogenous, their contribution lies in emphasizing the importance of a firm's ability to innovate new products. Recent work by Constantini and Melitz (2007) is the first example of a model of industry dynamics that includes endogenous innovation and export decisions. They show that anticipation of trade liberalization may lead firms to bring forward the decision to innovate, in order to be ready for future participation in the export market. This recent theoretical work emphasizing the importance of investment in product innovation as a key to explaining firm's productivity and its decision to start exporting is also backed by a number of empirical studies finding a positive impact of innovation on exporting [Wagner (1996), Wakelin (1997, 1998), Ebling and Janz (1999), Aw et al. (2005), Girma et al. (2007)]. A link leading from export participation to the learning effects, however, has yet to be demonstrated more convincingly. So far we have some evidence of a positive impact from export participation on either process innovations (Damijan et al, 2010) and productivity improvements (De Loecker, 2007; Damijan et al, 2010) for Slovenia only.

This, however, explains only a minor part of the puzzle of learning from trade participation. We still lack a consistent theory and evidence on (i) how firms learn from participating in trade, (ii) how it is related to firm innovation activities, and (iii) what (if at all) is the exact sequencing between innovation and trade participation. International business literature suggests that firms engaging in either import or export activities are likely to gain from the contacts with their suppliers and customers as well from the increased competition faced in larger foreign markets (Salomon and Shaver, 2005). It follows that a firm starting to export to foreign markets has to engage in adjusting to different technical standards and making ongoing quality improvements leading at least to improved product characteristics. But serving foreign markets with specific demand patterns may as well result in newly developed products tailor-made to the needs of specific markets. Based on the features of now standard new trade theories building on monopolistic competition and increasing returns to scale, exporting to a larger foreign market may enable firm to exploit the benefits of increasing returns to scale. This may go hand in hand with optimization of production processes, modernization of organization or introduction of new technologies, leading to improved technical efficiency. Exporting, hence, is likely to result in product and process innovations.

On the other hand, importing has attracted much less attention in empirical studies as a source of important knowledge spillovers. Recently, Amiti and Konings (2007) provide estimates of the effects of trade liberalization on plant productivity by distinguishing between productivity gains that arise from tougher import competition relative to those arising from access to cheaper intermediate inputs. By using the Indonesian microdata, they find that benefits arising from lower tariffs on intermediate inputs might have 10 times larger impact on firm productivity gains than that of increased import competition. Furthermore, studies by Altomonte et al (2008) using Hungarian microdata demonstrate that the impact of imports on firm performance is several times more important than the one stemming from firm's engagement in exporting. This study also shows a clear sequencing of firm trade participation. A firm engages in imports first by importing capital goods or intermediates as these goods are either not available at home at all or a firm can acquire these goods at a cheaper price abroad than at home. Exporting starts only later after a firm "dresses up" sufficiently in terms of productivity in order to bear the fixed entry cost to foreign markets.

While these productivity gains from importing seem plausible, it is less clear how they are related to firm innovation activities. Kotabe (1990) examines whether offshore sourcing by U.S. firms induces or dampens their innovative ability. By using industry level data, he finds some support for the complementarity between outsourcing and innovativeness of U.S. multinationals. Other related studies on firm imports and innovative activity deal with imports as a industry-wide competitive force which pushes firms to innovate in order to maintain their market position. By using German microdata, Bertschek (1995) shows that both import share and foreign-direct-investment-share industry-wide have positive and significant effects on firm product and process innovations due to increased local market competition. On the other hand, Aghion et al. (2005) build on the hypothesis by Kamien and Schwartz (1972) that the relationship between product market competition and the extent of innovation may take the form of an inverted U-curve. Specifically, their model assumes that increased competition discourages laggard firms from innovating, but encourages “neck-and-neck” firms to innovate. By using industry level data, Aghion et al. (2005) find support for the inverted U-shape relationship between competition and innovation. By using microdata for UK and U.S., Aghion et al. (2006) show that technologically advanced entry by foreign firms has a positive impact on innovation in sectors which are close to the frontier and that the effect of entry on total factor productivity growth is negatively associated with the distance to the frontier. Using microdata for 27 transition economies, Gorodnichenko et al (2008) don't find support for the inverted U effect of competition on innovation, but find that competition has a negative effect on innovation, especially for firms further away from the frontier, while the supply chain of multinational enterprises and international trade are found to be important sources for domestic firm innovation.

Based on the discussion so far we will argue that (i) learning from trade is associated with firm innovation activity, (ii) that there has to be a clear sequencing between various forms of trade links and the firm's innovation activity, and (iii) that these links have to be more pronounced the closer are the firms to the technological frontier. Regarding the first point, we draw upon the Aw et al. (2005), who argue that numerous studies that failed to find evidence of learning-by-exporting may have neglected a potentially important element of the process of productivity change: the investments made by firms to absorb and assimilate knowledge and expertise from foreign contacts. This means that exporting activity may have helped firms to become more innovative in their processes or products, which may impact productivity growth or firm survival in foreign markets in the long run. Accordingly, we alter the usual approach to study the learning from trade via firm total factor productivity growth. Instead, we define firm learning from trade as any introduction of a new product or a process following firm engagement in either import or export activities.

Regarding the second point, we argue that the sequencing of firm's learning from trade should go from (1) engagement in imports through (2) decision to start product or process innovation to (3) decision to start exporting and (4) to further product or process innovations induced by exports. And regarding the third point, we follow the implications of Aghion et al. (2005) and empirical findings by Aghion et al. (2006) and Gorodnichenko et al (2008) that the link between innovation and trade should be more pronounced for the firms that are closer to the technological frontier.

We first present a simple theoretical setup which allows us to gain additional insight into the issues involved. In a sequence, we then use microdata for Spain combining usual firm-level accounting data with the data on innovation and trade flows and employ propensity-score based matching and average treatment effects in order to explore the exact sequencing between firm's engagement in trade and its learning from trade through innovation.

3 The Model

We present a simple model of the decision to engage in innovation and to start exporting by heterogeneous firms. We build on Melitz (2003) model assuming a single monopolistically competitive sector with differentiated products produced with a single factor of production (labor). In the spirit of Krugman and Venables (1995), all final goods are allowed to enter firm's production as intermediates, which can substantially impact firms' marginal cost in the event of international trade. Following Yeaple (2005) and Bustos (2007), firms have the option of upgrading their technology by paying an additional fixed cost of research and development. Technology upgrades are associated with research and development expenditure, which in turn provide the basis for product or process innovations. New products and/or production processes enable firms to increase markups or improve productivity. In addition, firms are allowed to trade internationally by paying both fixed exporting and fixed importing costs. By importing intermediates from abroad firms can significantly reduce their marginal and total costs allowing for higher share of expenditures invested into technology upgrading. Both trading and technology upgrading are reinforcing each other through a process of ongoing productivity improvements.

3.1 Demand

As is commonplace in monopolistic competition models, we assume a representative consumer exhibits CES preferences over a continuum of varieties:

$$U = \left[\int_{i \epsilon I} q(i)^{\rho} di \right]^{1/\rho} \qquad 0 < \rho < 1 \tag{1}$$

where $q(i)$ is quantity of variety i and ρ is the substitution parameter. Consumers maximize their utility subject to the budget constraint, which yields demand for individual varieties

$$q(i) = \frac{E}{P} \left(\frac{p(i)}{P} \right)^{-\sigma} \qquad \text{where} \qquad \sigma = 1/(1-\rho) > 1 \tag{2}$$

where E is aggregate (country) income, $p(i)$ is the price of variety i and σ is the elasticity of substitution. The price index P is defined as

$$P = \left[\int_{i \epsilon I} p(i)^{1-\sigma} di \right]^{1/(1-\sigma)} \tag{3}$$

3.2 Production

On the production side, firms are monopolists in their respective varieties and their production technology features both marginal and fixed labor costs. Firms are heterogeneous in terms of productivity (indexed by ω) as they differ in marginal costs of production. In contrast to Melitz (2003), Yeaple (2005) and Bustos (2007) allow firms to upgrade their technology by paying an additional fixed cost, which reduces the marginal costs of production. This represents a deterministic choice between two different technologies (low l and high h). Firms that do not invest in fact opt for low technology, while firms that choose to invest in an upgrade receive high technology. Our approach differs somewhat from here on as we propose that investing in a technology upgrade only increases the probability of a technological innovation occurring. In that sense, the investment is thought as research and development expenditure, which does not ensure innovation but only improves the likelihood that it occurs.

Additionally, we propose that firms, in addition to labor, also use intermediate inputs in the production of their final product. Here we employ a commonly used (Ethier, 1982; Krugman and Venables, 1995; Venables, 1996) simplifying assumption that all final goods are also employed as intermediates in production[2]. Suppose the respective cost elasticities are μ for intermediate inputs and $1-\mu$ for labor. The total cost functions under each technology are therefore:

$$TC_l(\omega) = w^{1-\mu}P^{\mu}\left[f + \frac{q(\omega)}{\omega}\right] \tag{4}$$

$$TC_h(\omega) = w^{1-\mu}P^{\mu}\left[f\eta + \frac{q(\omega)}{\phi\gamma\omega + (1-\phi)\omega}\right] \tag{5}$$

$$\text{where } \varphi > 0 \text{ and } \gamma, \eta > 1$$

where ϕ is the probability of a successfully product or process innovation, γ measures the impact of higher technology on productivity[3] and η measures the additional cost of research and development. The expected productivity of R&D performing firms is therefore always higher than that of firms that chose not to invest in R&D ensuring that the main results of the model do not differ from those in Bustos (2007). Whereas technology enhancing investment necessarily improves the technology of the investing firm in Bustos (2007), according to our approach it only improves the likelihood of a product or process innovation, but does not ensure successful innovation.[4] ϕ is firm specific and can depend on absorptive capacity, number of previous innovation successes, horizontal and vertical spillovers from other firms, importing and exporting status, share of R&D in sales, share of R&D workers in total employment, etc. Technology upgrading, though the same for all firms, benefits more productive firms more than less productive ones, which is evident from the profit condition for using technology h

$$\pi_h(\omega) > \pi_l(\omega) \iff \frac{1}{\sigma}E(P\rho)^{\sigma-1}\omega^{\sigma-1}\left((\phi\gamma + (1-\phi))^{\sigma-1} - 1\right) > w^{1-\mu}P^{\mu}f(\eta - 1) \tag{6}$$

3.3 Trade

As in Melitz (2003) firms face additional fixed costs of exporting f_e and variable iceberg transport costs τ in reaching the export markets. This ensures the usual productivity ordering of

[2] Manufactures is using its own output as input.

[3] This effect could manifest itself as either product innovation leading to improved products (with higher markups), or process innovation leading to higher productivity of labor.

[4] Our assumption leads to the result that firms that do not invest in research and development will not innovate i.e. have zero chance of becoming succesful innovators.

more productive firms into exports and less productive firms serving domestic market only.[5] The benefit of R&D investment is proportional to a firm's variable profits, which are higher for exporting firms than for non-exporters. This implies that exporting status increases the profitability of technological adoption making firms more likely to invest in R&D if they are exporters. The underlying reason for the enhanced impact of technological upgrading on exporters is the larger platform in terms of production and sales which gets effected by the productivity improvement. On the other hand, higher productivity level of firms investing in R&D ensures that they are more likely to meet the exporting productivity cut-off requirement and start exporting. Investing in a technology upgrade therefore also improves the likelihood of becoming an exporter.

Finally, we also introduce importing into the model. As with exporting and innovation, we assume that firms face additional fixed cost of becoming importers. This can be interpreted as cost of searching for a suitable foreign supplier, cost of adjusting the production line in order to use imported intermediates in production, etc. Given the comparably higher costs of establishing exporting supply routes, we assume that the fixed cost of importing (f_{im}) is smaller than the fixed cost of exporting (f_e) On the other hand, importers' gain by utilizing cheaper intermediate inputs as the price index of the broader market (domestic and foreign market combined) has a lower price index than the domestic market alone. Assuming that home and foreign country share the same productivity distribution and elasticity of substitution, but the foreign market is m-times the size of the domestic market, then the combined price index becomes

$$P_T = \left[(1+m) \int\limits_{i \epsilon I} p(i)^{1-\sigma} di \right]^{1/(1-\sigma)} . \tag{7}$$

Since the $1/(1-\sigma)$ is always negative, P_T is smaller than P if $m > 0$. The resulting price index enables importers to benefit from lower marginal costs due to lower costs of intermediate goods as compared with non-importers. Taking into account the fixed cost of importing and assuming identical productivity distribution functions between the two countries, the size of the foreign market allows us to write the condition for becoming an importer (assuming low technology).

$$\pi_l^{im}(\omega) > \pi_l(\omega) \iff f + \frac{q(\omega)}{\omega} > (1+m)^{\frac{\mu}{1-\sigma}} \left[f + f_{im} + \frac{q(\omega)}{\omega} \right] \tag{8}$$

Firms with productivity exceeding the treshold defined by (8) will choose to start importing, whereby the benefits of being an importer increase with the increased productivity. Importing status therefore helps reducing the marginal cost of production for all firms that are able to bear the fixed cost of starting to import. Firms that become importers are subsequently likelier to upgrade their technology as reduced marginal costs lower the right-hand side of the condition for technology upgrading (6), which in turn reduces the productivity threshold for new innovators. Importing status, through lower intermediate costs, hence ensures that the cost of research and development is lower[6] Finally, a reduction in the price index will also reduce the fixed costs of starting to export for all perspective exporters by lowering the required productivity of new exporters. Importing status will hence improve both the probability of becoming an innovator as well as the probability of starting to export.

[5] The productivity requirement for becoming an exporter is described by

$$\pi_l^{do}(\omega) < \pi_l^{ex}(\omega) \iff \tau^{1-\sigma} \frac{1}{\sigma} E(P\rho)^{\sigma-1} \omega^{\sigma-1} > w^{1-\mu} P^{\mu} f_e$$

[6] Alternatively, the benefits of importing can be interpreted in terms of higher quality of imported intermediate inputs for the same price as domestic (lower quality) inputs.

3.4 Implications of the model

This relatively simple theoretical framework generates a rich set of implications for studying the relationship between trade and innovation. The model suggests a clear sequencing between imports, exports and innovation. A firm with sufficiently high productivity to pay the cost of starting to import will benefit from the lower price of intermediates reducing the marginal cost of production and resulting either in increased productivity or a higher cost savings in production. As can be seen from (5), the increased productivity or lower share of cost of production increase the probability of a firm to invest a higher proportion of expenditures into R&D and hence increase the probability of successful innovations. At the same time, these innovations result in firm's technology upgrading and further improvements in productivity, which in turn increase the probability of a firm to start exporting. Of course, engagement in exports perpetually increases the probability of further investments into R&D, resulting in increased potential for innovations and productivity improvements.

This clear productivity ordering of importers, exporters and innovators, which is demonstrated by the empirical evidence (see Crepon et al., 1998; Cassiman and Golovko, 2007; Damijan et al., 2010, etc.), hence suggests that empirical studies searching for learning from trade should focus on the complete chain of links between imports, exports, innovation and productivity. While as deterministic in the initial stage as the Melitz (2003) and Constantini and Melitz (2007) setup in the sense that the initial productivity is assigned to firms exogenously by the luck of draw, our model allows for stochastic evolution of firm dynamics once a firm engages in international trade. As the fixed cost of starting to import is arguably lower than fixed cost of starting to export, it is obvious that a firm will first engage in imports than in export activities.[7] It is imports that allow firm first to learn the international markets as well as to benefit from lower price (higher quality) of intermediates and hence to shift the cost savings in production into the increased expenditures for R&D. From here on, firm dynamics is indeterminate as the firm may be lucky to turn the increased R&D expenditures into successful innovations or not. The same reasoning applies to firm's export engagement. Obviously, firm's engagement in trade may not lead to immediate productivity improvements, but may instead increase firm's ability to "learn" from trade by allowing for increased investments into R&D and hence for increased probability of innovation. Innovation may the eventually result in productivity improvements. This is why in this paper we refer to learning from trade in the form of firm innovations instead of productivity improvements.

4 Data and sample characteristics

4.1 Data

In order to test the predictions of our theoretical setup, the paper uses a very rich survey data for Spanish manufacturing firms during the sample period 1991-1999. The Spanish dataset from the Encuesta Sobre Estrategias Empresariales (ESEE) is an unbalanced sample of firms collected using direct interviews with a questionnaire. For firms with less than 200 employees a random sample of survey participants is drawn ensuring the representativeness of the industrial and size categories[8]. The sample for large firms (above 200 employees) includes the whole population of large manufacturing firms. Our sample includes 16,649 firm-year observations ranging from 1702 and 2059 observations per year between 1991 and 1999. This dataset (or a very similar one) has been used extensively by other authors[9]. In addition to accounting data on the surveyed firms, the ESEE also provides information on the innovative activity of manufacturing firms,

[7] Refer to Altomonte et al. (2008) for the pattern of trade of Hungarian firms.

[8] The ESEE survey does not include firms with less than 10 employees.

[9] Gonzales, Jaumandreu et al. 2005; Salomon and Shaver, 2005, Cassiman and Martinez-Ros, 2007 and Cassiman and Golovko, 2007 among others.

imports, exports and foreign ownership. Most importantly from the perspective of this paper, we dispose with information on whether a firm has come out with product or process innovations, the number of these innovations, R&D expenditures, royalties paid and received etc.

[Insert Table 1 here]

4.2 Sample characteristics

A first glance at the properties of the dataset reveals that the sampled firms differ in their characteristics according to their exporting and importing status and innovating activity. Firms that were active importers and exporters and have also innovated were found to have the highest labor productivity, while also being larger both in terms of sales as well as employment. On the other end of the spectrum, firms that engaged in neither international trade nor innovative activity were found to be the smallest and least productive.

[Insert Table 2 here]

An overview of the interaction between importing and exporting status and innovative success is given in the form of simple correlations in Table 2. Unsurprisingly, importing and exporting status are highly correlated with the respective correlation coefficients at 0.70. Furthermore, both importing and exporting status is correlated with innovation activity irrespective of whether product or process innovations are considered. About one fifth to one quarter of the variation in the exporting and importing dummies can be explained by either product or process innovation dummies. This reinforces our initial belief that the importing and exporting status, and innovative activity are related, but the direction of causality between them has yet to be discovered.

In order to provide additional insight into the possible causal relationships in the data we study the transitional probabilities between trade participation and innovation. We do this by looking into three hypothesized sequences between trade participation and innovation activity of firms. The first sequence shows probabilities of importing firms in $t-1$ or $t-2$ of becoming innovators in period t. The second sequence shows probabilities of innovative firms in $t-1$ or $t-2$ of starting to export in period t. And finally, the third sequence shows probabilities of exporters in $t-1$ or $t-2$ to start innovating in period t. For the sake of convenience, we will refer to this direction of causal sequences between trade participation and innovation as "*Type 1*" sequencing. For the sake of completeness, we will also check transition probabilities between trade - innovation states when the first sequence starts with firms which engage in trade by exporting first and only latter start importing and innovating. We label this second direction of causality as "*Type 2*" sequencing.

[Insert Table 3 here]

Table 3 presents transition probabilities in the Type 1 sequencing, which starts with import starters. The table reveals that in the sample of Spanish firms there is quite important mobility of firms between different trade participation and innovation states. In the first sequence, about 6.7 and 14 per cent of firms being importers but not innovators in $t-1$ or $t-2$ become product or process innovators in t, respectively. The fraction of firms that are neither importers nor innovators in $t-1$ or $t-2$, but start product or process innovating in t, is lower by about 30 - 40 per cent (the respective figures are 4.4 and 8.7 per cent). This indicates that lagged importing experience may significantly affect firm's future ability to innovate. In the second sequence, between 42 and 47 per cent of importing but not exporting firms, which started (product or process) innovating in $t-1$ or $t-2$, start exporting in t. This is to be compared to about 32 per cent of non-innovators in $t-1$ or $t-2$ which start exporting in t. In other words, while there is a one-third probability that recent import starters will start exporting within a two-year time span, this probability increases to almost 50 per cent if import starters are engaged in any kind of innovation activity. And in the third sequence, 50 and 44.5 per cent of firms that started exporting in $t-1$ or $t-2$ introduce additional product and process innovations in t, respectively. Controlling for the past import and innovation status, the fraction of firms that do not start exporting in $t-1$ or $t-2$ is actually quite similar to the fraction of first-time exporters that introduce additional innovation. For process innovations the figures are similar, while for product innovations the fraction of new exporting firms introducing additional innovations is slightly higher than for non-exporters (50 versus 43 per cent, respectively). This indicates that innovation activity is very persistent once firms have become innovators, but starting to export might still boost additional product innovations that would not be there without the exporting experience of firms.

[Insert Table 4 here]

Table 4 shows transition probabilities for the Type 2 sequencing, where the first sequence starts with firms, which engage in trade by exporting first. What is striking there is that in absolute terms there is more mobility of firms between states when the first sequence starts with importing (Type 1) rather than with exporting (Type 2). The number of firms in the whole sample and number of firms participating in the switching between states is larger in the Type 1 sequencing by about 10 - 30 per cent across different stages of sequencing. In relative terms, the differences are smaller. In the first sequence, about 6.8 and 11.8 per cent of firms being exporters but not innovators in $t-1$ or $t-2$ become product or process innovators in t, respectively. This is similar but slightly smaller when compared to the figures for Type 1 sequencing. The fraction of firms, which were not engaged in exports but introduced new innovations is about half the size of the former. Dissimilarities are larger when comparing the higher-levels of the sequencing. In the second stage of the sequence, the probability of newly innovative firms to start importing is about 32 per cent for firms that have recently started product innovations and about 21 per cent for recent process innovating firms. These probabilities are markedly lower than those found in the Type 1 sequencing (from innovation starters to export starters), where the figures are between 42 and 47 per cent. On the other side, probability of recently innovative firms to become importers is significantly different relative to non-innovating firms only for firms that have innovated products, but not for process innovating firms. The third stage of the sequence is even more peculiar as the probability of new importers (with past innovations) to introduce additional innovations is at most similar (product innovations) or significantly lower (process innovations) than for non-importing firms. This departs from the first sequence in Type 1 sequencing, where import status is shown to have a significant effect on new innovations.

Comparison of transition probabilities across both directions shows that the mobility of firms in terms of switching trade participation - innovation states is larger when firms start with the import status first (Type 1) than if they start as exporters first (Type 2). Therefore, we may expect larger effects of switching states when observing the sequencing through Type 1 rather than through Type 2 direction.

5 Methodology

In order to account for the causal relationship between international trade (importing and exporting status) and innovation, we want to test whether importing status/exporting status enhances the probability of successful innovation and vice-versa. We explore the direction of causality by allowing for the sequencing between trade and innovation in three stages. In Type 1 sequencing, we first examine the impact of lagged importing status ($t-1$ or $t-2$) on the probability of becoming a first-time successful innovator (product or process innovators) or becoming an exporter in t. Secondly, we test whether lagged first-time innovation status impacts the probability of becoming a first-time exporter in the current period. Finally, we explore the effect of first-time exporting status on the probability of introducing additional innovations. We also check the other direction of sequencing starting with the export status in stage one (Type 2). While we provide a brief review of our econometric approach here, a more detailed look at the identification strategy and variable description is given in the appendix.

We employ matching techniques based on propensity scores to check whether there exist the proposed sequencing pattern between imports, exports and innovation. The matching techniques enable the selection of a valid control group. The purpose of matching is to pair importing (first-time exporting and first-time innovating) firms on the basis of some observable variables with non-importers (non exporters, non-innovators). Given the variety of firm observables (productivity, size, ownership, industry and time effects) that could potentially serve as a basis for matching, one encounters the dimensionality problem. The problem of having too many possibilities for matching (too many dimensions) can be resolved by applying propensity score-matching (Rosenbaum and Rubin, 1983), which uses the probability of receiving a given treatment, conditional on the pre-entry characteristics of firms, to reduce the dimensionality problem (a single index hence replaces all of the pertinent observable firm characteristics).

The propensity score specification we use to describe the decision to import is given by[10]

$$P(Imp_t = 1) = f(va\_emp_{t-1}, k\_emp_{t-1}, emp_{t-1}, fdi_{t-1}, sec, time_t) \tag{9}$$

where Imp_t is an indicator of whether a firm is an importer at time t ($Imp_t = 1$) or not ($Imp_t = 0$). In this stage we only consider those importers (non-importers) that were not yet exporters or successful innovators[11]. va_emp_{t-1} is the lagged value added per employee, k_emp_{t-1} is lagged capital per employee, emp_{t-1} is lagged size (in terms of employment) and fdi_{t-1} is the lagged foreign ownership status (if at least 10% of capital is foreign owned the variable assumes value 1, 0 otherwise). sec are dummy variables for industrial sectors (NACE revision 1 2-digit industries), while $time_t$ are year dummies.

The propensity score specification for decision to start innovating is similarly given by

$$P(Inov_t = 1) = f(RD/Sal_{t-1}, va\_emp_{t-1}, k\_emp_{t-1}, emp_{t-1}, fdi_{t-1}, sec, time_t) \tag{10}$$

where $Inov_t$ is an indicator of whether a firm has successfully innovated for the first time in period t ($Inov_t = 1$) or not ($Inov_t = 0$)[12]. RD/Sal_{t-1} is lagged R&D expenditures relative to firm sales, while the remaining variables are the same as above. Similarly as above, we only consider those innovating firms that were not yet exporters up to this point in time. Based on (9 and (10) we proceed to match importers with non-importers and innovators with non-innovators to see whether either lagged importing status or lagged successful innovation has an impact on the likelihood of becoming and exporter. Firms with similar likelihoods of being importers (or innovators) are matched within the same year-sector space. Sectors are defined as NACE 2-digit industries, which may be too broad a definition of a sector, but going to a more disaggregated level would severely limit the number of year-sector observations and limit the scope for credible

[10] Note that the propensity score specifications are independent of the directions of sequencing as they do not include the treatment variables on the right-hand-side. We apply the same specification in Type 2 sequencing for import starting firms at time t.

[11] Excluding firms that were already innovating and exporting will allow us to get a clearer picture of the direction of causality between importing, innovation and exporting.

[12] We differentiate throughout between product and process innovations and employ separate propensity score specifications for the two types of innovation.

average treatment estimates. This specification satisfies the balancing property ensuring that the two cohorts do not differ substantially with respect to the regressors in respective blocks. We use nearest neighbor matching to find the most similar firms and analyze the effects of the treatment variable although regressions with other types of matching procedures (such as kernel and radius matching) have yielded very similar results.[13]
On the other hand, we test effect of exporting and importing status on the probability of becoming a successful product or process innovator. For that purpose, we additionally specify the following propensity score specifications for exporting status

$$P(Exp_t = 1) = f(va\_emp_{t-1}, k\_emp_{t-1}, emp_{t-1}, fdi_{t-1}, sec, time_t) \tag{11}$$

where Exp_t is an indicator variable of first-time exporting status of the firm at time t. Firms that have become exporters for the first time in period t have a value of 1, non exporters 0. We explicitly differentiate between product and process innovators by running two separate specifications (one for first-time product and one for first-time process innovators). Again, the propensity score estimates from (9) and (11) are employed to match importers and non-importers and exporters with non-exporters to assess the impact of lagged exporting and importing status on the probability of becoming an innovator and vice versa. Instead of presenting the results separately for each industry-year pairing, we only show aggregate results for the entire sample with the averages weighted by the number of observations in a industry-year pairing.

In order to test whether the assumption of conditional independence is satisfied in our different specifications, we determine the reduction of median absolute standardized bias brought about by the use of matching[14] (Becker and Egger, 2007). Rosenbaum and Rubin (1985) suggest the remaining bias should not exceed 20 per cent. In our case the median absolute standardized bias in case of the propensity to import amounts to only 2.8% for the Spanish dataset, while in case of the propensity to innovate (all innovation, product and process innovation separately) it equals 2.5%, and finally, in case of the propensity to start exporting to 17.5%. In all three cases the remaining bias is well within the suggested bound of 20%. Overall, our matching procedures reduce the bias by about 66% as compared with the initial sample. Furthermore, a comparison of pseudo-R^2 of the propensity score estimation before and after matching reveals a significant reduction in the explanatory power of these estimates in all specifications and size classes. In all specifications the explanatory power is substantially reduced by at least 20%. This indicates that in the matched sample of treated and control units there is no longer any systematic difference in observables between the two cohorts of units, leading us to conclude that our matching procedure satisfies the balancing property and the conditional independence assumption is not violated.
Previous studies using these datasets for Spain and other countries (such as Slovenia, see Damijan, Kostevc and Polanec, 2010) have demonstrated that the results either for the decision to start exporting or the decision to start innovation are associated with the firm size. We therefore split our dataset into three subsamples according to the standard size classes. The first subsample consist of small firms with less than 50 employees. The second one comprises medium sized firms with number of employees between 50 and 200, while the third size class contains large firms with more than 200 employees. To ensure comparability over time, each firm is classified into a specific size class according to its average number of employees over the period. In what follows, we report the results separately for each size class.

In addition, the literature review has demonstrated that there might be non-linear relationship between trade participation and innovation impacted by firm's distance to the technology frontier. We therefore split our dataset into five quintiles according to the level of firm productivity and run separate tests for the bottom (laggard firms) and the top quintile (front runners).

[13] These results are not presented here for the sake of brevity.

[14] We calculate the median absolute standardized bias in the observables included in the selection specification between the treated firms and all control observations compared with the treated and matched control units.

The results are presented separately for each subsample. Finally, following Abadie and Imbens (2008) we use subsampling to generate the standard errors of average treatment effects whenever the sample size (of either the sample of treated or control firms) falls bellow 100 observations.

6 Results

In this section we present results for average treatment effects of the four status variables on the likelihood to switch status. We first present pooled results which are summarized in Table 5 for both directions of sequencing, while next subsections present results accounting for firm size and the distance to technological frontier. The results are standardized across all tables presented here, so that the first three columns indicate the sequencing stage, the treatment variables and outcome variables, respectively. Next two columns (the fourth and fifth) contain the number of treated and control observations, while coefficient on average treatment effect is presented in the sixth column and the related standard errors are given in the final column.[15]

Note that all treatment variables are lagged relative to the year of export/import entry or the year of successful product or process innovation by one or two years. We assign a firm to have started innovation or trade in the period $t-s$ $(s=1,2)$ if this switch from non-innovation to innovation status and from one trading mode to another (from imports to exports, and vice versa) has occurred within the last two years.[16] This is partly due to relatively short data samples, but predominantly due to the fact that the change in status may take time before it affects firm's processes and performance.

[Insert Table 5 here]

In accordance with the implications from the transitional probabilities presented above, one can depict two general trends in the pooled results of treatment effects over all firms. First, we find strong support in favor of the proposed causal sequencing between trade and innovation. This sequencing, however, seems to be more pronounced in the Type 1 sequencing starting with the import status than in the alternative sequencing direction starting with the export status (Type 2). In Type 1, all three stages show significant causal relationship between different trade and innovation states, while in Type 2 significant treatment effects are found in the first stage and only partly in stages 2 and 3. Second, more specifically, pooled results for Type 1 sequencing confirm our belief that sequencing from imports over innovation to exports and from exports to additional innovations is more likely. In the first stage, lagged import status is shown to affect significantly firms' decision to start innovation (product and process) as well as to engage in exports. A higher likelihood is found for importers to introduce product than process innovations. This is somehow at odds with the expectations (and the implications from the transition probabilities) that importing capital goods and intermediates will more likely impact firm efficiency through process innovations rather than affect the firm product mix. On the other side, even larger effect is found for imports affecting firm decision to start exporting. In the second stage, both product and process innovations, which were boosted by firm past engagement in imports, are shown to impact firm decision to start exporting. Again, firms with recent product innovations are about three-times more likely to start exporting than firms that have innovated processes. Finally, recent first-time exporters, which became

[15] Note that in the sequencing process we also controll for the cross-sequence effects. In the first sequencing stage of Type 1 sequencing, we allow for the fact that importing firms not only start innovating (product and process), but may also start exporting simultaneously. The details on how these observations are treated are provided in the Appendix. Suffice it to say that the results are qualitatively no different from our baseline estimates when these firms are included.

[16] Technically, we ensure this by allowing for an additional lead year in the outcome variable, rather than lagging the treatment variable. This is done in order to maintain the consistency of the propensity score specifications.

exporters through innovation, are shown to introduce additional products, but not necessarily to introduce additional process innovations. Alternatively, first-time exporters, which became exporters directly through importing, are likely to innovate processes but not necessarily the products. On the other hand, in Type 2 sequencing, recent new importers that became importers directly through exporting status (without becoming innovators first) are shown to introduce both product and process innovations, while this does not hold for firms that became importers indirectly through innovation.

6.1 Accounting for firm size

Results by size classes (see Tables 6 and 7) support the observed impact of cross-border involvement on successful innovation, but reveal also that it is mainly driven by small and partially by medium-sized firms. This holds for both directions of sequencing. In Type 1 sequencing, imports matters for the probability to start either product or process innovations and exports for small firms only, whereby for medium firms imports induces exports only, and has no impact at all on large firms. In the second stage of Type 1 sequencing, product innovations are shown to drive firm decision to start exporting in all three size classes, while process innovations have no or have even a negative impact on the exports start. In the third stage, export start seems to boost additional innovation only in the sample of the small firms, while for medium and large firms these effects are not systematic and can even be negative. Results are almost identical for sequencing between trade participation and innovation along the Type 2 alternative.

[Insert Table 6 here]
[Insert Table 7 here]

One can explain these findings with the fact that a majority of large firms are already engaged both in imports, exports as well as in innovation activities.[17] This does not leave much scope for switching either the trade or innovation status.

6.2 Accounting for the distance to technology frontier

Firm size was shown to have a significant impact on the relationship between importing status, exporting status and innovative activity. As shown by the large body of the empirical literature, firm's relative productivity or its distance from the relevant technological frontier can substantially alter its behavior both in terms of when it chooses to enter foreign markets as well as whether or not to import materials and capital goods. In addition, the productivity level can also be correlated with the firm's absorptive capacity which can affect the dynamics of both the adoption of technology and own innovation. As demonstrated by several empirical studies (Carlin et al, 2004; Aghion et al, 2006; Gorodnichenko et al, 2008), a firm's innovation activity may well depend upon its distance to the relevant technology frontier.
In order to analyze the importance of firm relative productivity, we test the above relationships for both the productivity laggards and front-runners. We first estimate total factor productivity as a residual of

$$\ln(va_t) = \alpha + \beta_1 \ln(k_t) + \beta_2 \ln(l_t) + \varepsilon_t$$

where va_t represents value added, k_t is capital and l_t is labor. We allow the coefficients β_1 and β_2 to vary across NACE 2-digit industries and periods of observation. Based on the estimated total factor productivity, we test the relationship between importing status, probability of becoming

[17] Damijan and Kostevc (2006) show that the share of exporters among large firms in bigger, while Damijan et al (2006) demonstrate that large firms are 2-3 times more likely to conduct innovation activities.

a new exporter and the probability of becoming a first-time innovator separately on industry-leaders and laggards. We define the front-running firms as those in the top quintile of the industry's productivity distribution, with the laggards being those in the bottom quintile of the respective industry-year pair.

[Insert Table 8 here]

Table 8 presents the results for the Type 1 sequencing between importing, innovation and exporting for the respective cohorts of industry front-runners and laggards for Spanish firms. The estimates reveal notable differences between the cohorts of industry laggards and leaders in terms of productivity. We find that there is a statistically significant effect of lagged importing status on the probability of starting to innovate only for productivity front-runners while the effect is no longer significant for laggard firms. Both groups of firms experience a significantly higher likelihood of becoming first-time exporters than their non-importing counterparts, but the effect for the front-runners is shown to be twice as high as that of the laggard firms. Similarly, only importing firms at the productivity frontier experience a significantly higher likelihood of becoming first-time exporters if they have successfully innovated products (but not processes) in the previous periods. Finally, in stage 3, lagged export-starter status (after being importer and innovator) does not improve the likelihood of introducing additional future innovations for the front-runners, while there is some significant effect of becoming innovator for the laggard firms, which have not innovated previously. This indicates that a learning process for laggard firms may be longer than for front-runners. While firms at the technology frontier are likely to start innovating already after becoming importers, the laggard firms have to become exporters first (after being importers) and only then start innovating.

[Insert Table 9 here]

The estimates for the Type 2 sequencing are presented in Table 9. Results are qualitatively comparable to the results for sequencing along the Type 1 alternative. There are some significant effects in sequencing between trade states and innovation recorded for the front-runners only, while there is almost no significant relationship found for the laggard firms.[18] More specifically, in stage 1, lagged exporting status is shown to improve the likelihood of front-running firms to become first-time product innovators (but not process innovators). Among the front-runners, both product and process innovators with past import status are then in stage 2 shown to be more likely to become importers. In stage 3, new importers who have innovated before are not more likely to introduce additional innovations when compared to non-importers. Adversely, there is some evidence that recent new importers who have not innovated so far may become product (but not process) innovators in stage 3.

The results presented, hence, provide some support to the proposed sequencing between trade states and innovation. This sequencing, however, is shown to be more pronounced (1) when firms start with the imports engagement first, (2) for small firms, and (3) firms at the technology frontier. These results are consistent with the results of Damijan et al (2010), which find that for small and medium-sized Slovenian firms exporting increases the probability of inducing innovations. It is evident that the traditional learning-by-exports story is more complex than it was dealt with in the empirical research so far. The studies by Aw et al (2008, 2009), Damijan et al (2010) and this one may be a useful framework to study the growth dynamics of firms engaged in international trade.

[18] The only significant effect goes from past export status to import-starter status.

7 Conclusions

This paper explores the learning effects of firm's participation in trade. We argue that one should study both the import as well as the export engagement of firms in international firms since both may have important beneficial effects for firm performance. In addition, the learning effects of firm's participation in trade are studied through the channels of firm innovations. In line with Aw et al (2005, 2008) we believe that a firm may learn through its international contacts and demand - supply chains, which may in turn be reflected in its innovation efforts in terms of new products or new processes. These innovations, however, do not necessarily immediately translate into firm productivity improvements, but this learning from trade may impact productivity growth or firm survival in foreign markets in the long run. In this respect, we argue that it is important to study the sequencing of firm's participation in trade and subsequent learning effects. This sequencing of firm's learning effects from trade is likely to go from (1) engagement in one trade mode (either imports or exports) through (2) decision to start product or process innovation to (3) decision to start the other trade mode (exports or imports) and finally to (4) further product or process innovations induced by trade engagement.

We use microdata for Spain combining usual firm-level accounting data with information on innovation and trade flows and employ matching to explore the exact sequencing between firm's engagement in trade and its learning from trade through innovation. We study the sequencing through both directions. In Type 1 the sequencing starts with the import status, while in Type 2 it starts with the exports status. Our empirical exercises provide strong support for the proposed sequencing between trade states and innovation. The results can be summarized as follows. First, while there is clear evidence of sequencing running in both directions, there is stronger support in the data for sequencing running from imports through innovations to exports and to further innovations. Second, this sequencing is more pronounced for small and partly for medium-sized firms. And third, firms closer to the relevant technological frontier are more likely to benefit from this learning processes through internationalization.

Our results indicate the importance of import links for smaller firms enabling them to learn both in terms of the production processes as well as in order to improve their product characteristics. This may help firms to dress up for the consequent entry to foreign markets with their products. This results are in line with the recent theoretical work by Constantini and Melitz (2007) trying to enrich existing models of international trade of heterogenous firms by allowing for firm's endogenous innovation, which may explain what makes some firms "better" and more suitable for their decision to start exporting. Previous learning from the engagement in imports might be the key for smaller firms, but as shown above, the whole sequencing chain is important in order to understand firm's learning effects from trade.

In terms of policy recommendations, this paper implies that government policies should focus on small and medium-sized firms in order to promote both their internationalization processes as well as their innovation activities. While large firms can either use their own assets or borrow assets in financial markets to bear the cost of financing trading and R&D activities, small and medium-sized firms are more financially constrained. Government policies should hence assist small and medium-sized firms with a range of policy measures, such as special internationalization funding schemes, special training schemes for new exporters, and provision of information on potential import and export partners. On the other side, targeted R&D subsidies and tax credits for R&D expenditures would substantially lower the cost of R&D activities of small and medium-sized firms.

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8 Tables to be included into text

Table 1: Characteristics of the Spanish sample in 1999 (mean values apart from the number of firms)

	innovating firms				non-innovating firms			
	exporters		non-exporters		exporters		non-exporters	
	imp=0	imp>0	imp=0	imp>0	imp=0	imp>0	imp=0	imp>0
VA_emp	5.61	1.40	2.91	1.59	4.09	1.53	4.21	3.24
K_emp	6470.4	16065.1	6004.0	11292.1	8834.1	15408.4	5583.2	7977.7
size (employment)	82.70	500.14	36.35	145.07	68.51	292.01	35.79	64.99
size (revenue)	1,590,971	20,013,278	496,569	4,957,993	1,916,835	11,064,972	569,853	1,700,946
number of firms	77	541	115	82	95	382	1,799	104
no. of prod. innov.	2.75	9.90	1.22	2.47	0	0	0	0
no. of proc. innov.	5.90	6.13	6.23	6.02	0	0	0	0

Note: VA_emp and K_emp in current Spanish pesetas
Source: ESEE, own calculations.

Table 2: Correlation between importing, exporting and innovation for Spain

	imp dum	exp dum	prod.inn.	proc.inn.	#prod.inn.	#prod.inn.
imp dum	1					
exp dum	0.7021*	1				
prod.inn.	0.2253*	0.2449*	1			
proc.inn.	0.2102*	0.2085*	0.3326*	1		
#prod.inn.	0.0590*	0.0685*	0.2177*	0.0699*	1	
#proc.inn.	0.2200*	0.2196*	0.3418*	0.9900*	0.0716*	1

Note: * indicates statistical significance at 1%
Source: ESEE and SORS; own calculations.

Table 3: Transitional probabilities between trade participation and innovation for Spain; Type 1: Imports –>Innovation –>Exports

import status $(t-s)$	start to product in.(t)		start to process in.(t)	
	0	1	0	1
0	1,812 (95.6)	83 (4.4)	1,731 (91.3)	164 (8.7)
1	392 (93.3)	28 (**6.7**)	361 (86.0)	59 (**14.0**)
start to innov. product $(t-s)$	start to export (t)			
	0	1		
0	543 (67.9)	257 (32.1)		
1	57 (53.3)	50 (**46.7**)		
process $(t-s)$	0	1		
0	428 (68.0)	201 (32.0)		
1	90 (58.1)	65 (**41.9**)		
start to export $(t-s)$	start to product in.(t)		start to process in.(t)	
	0	1	0	1
0	55 (56.7)	42 (43.3)	77 (55.4)	62 (44.6)
1	46 (50.0)	46 (**50.0**)	66 (55.5)	53 (**44.5**)

Note: Number of firms, percentage of firms across rows in brackets.
Source: ESEE, own calculations.

Table 4: Transitional probabilities between trade participation and innovation for Spain; Type 2: Exports –>Innovation –Imports

export status $(t-s)$	start to product in.(t)		start to process in.(t)	
	0	1	0	1
0	1,649 (96.9)	52 (3.1)	1,649 (92.4)	136 (7.6)
1	315 (93.2)	23 (**6.8**)	315 (88.2)	42 (**11.8**)
start to innov. product $(t-s)$	start to import (t)			
	0	1		
0	325 (78.7)	88 (21.3)		
1	28 (68.3)	13 (**31.7**)		
process $(t-s)$	0	1		
0	325 (78.7)	88 (21.3)		
1	48 (78.7)	13 (**21.3**)		
start to import $(t-s)$	start to product in.(t)		start to process in.(t)	
	0	1	0	1
0	16 (57.1)	12 (42.9)	15 (51.7)	14 (48.3)
1	71 (57.7)	52 (**42.3**)	89 (59.3)	61 (**40.7**)

Note: Number of firms, percentage of firms across rows in brackets.
Source: ESEE, own calculations.

Table 5: Pooled average treatment effects of nearest neighbor matching across all manufacturing firms

Direction 1: Imports -> Innovation -> Exports

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Import status (not export or innov in t-s)	Export start (no innov)t	607	1729	0.087***	0.015
		Prod. innov start (no export)t	607	1878	0.047***	0.017
		Proc. innov start(no export)t	607	1878	0.023*	0.013
Stage 2	Prod. innov starter (in t-s)	Export start (importer)	855	786	0.099***	0.020
	Proc. innov starter (in t-s)	Export start (importer)	946	627	0.035*	0.020
Stage 3A	Export starters (import in t-s, no innovation)	Prod. innov start (importer)t	231	332	-0.028	0.027
		Proc. innov start(importer)t	231	332	0.097**	0.040
Stage 3B	Export starters (import and innovate in t-s)	Add. future prod. innov	767	94	0.124***	0.029
		Add. future proc. innov	767	137	0.024	0.028

Direction 2: Exports -> Innovation -> Imports

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Export status (not import or innovate in t-s)	Import start (no innov)	384	1001	0.103***	0.020
		Prod. innov start (no import)t	561	1730	0.032*	0.017
		Proc. innov start(no import)t	561	1647	0.021*	0.012
Stage 2	Prod. innov starter (in t-s)	Import start (exporter)	276	372	0.091***	0.032
	Proc. innov starter (in t-s)	Import start (exporter)	432	393	-0.002	0.024
Stage 3A	Import starters (export in t-s, no innovation)	Prod. innov start (exporter)t	538	369	0.055***	0.021
		Proc. innov start (exporter)t	538	395	0.080***	0.028
Stage 3B	Import starters (export and innovate in t-s)	Add. future prod. innov	1194	28	0.042	0.033
		Add. future proc. innov	1194	29	-0.044	0.036

Note: Subsampling based standard errors (500 repetitions, subsample size is 80% of the total sample) whenever either the number of control or treated observations is less than 100.

Source: ESEE, own calculations

Table 6: Average treatment effects of nearest neighbor matching for manufacturing firms by size classes (Type 1: imports-innovation-exports)

Small firms (with at most 50 employees)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Import status (not export or innov in t-s)	Export start (no innov)t	421	1541	0.112***	0.019
		Prod. innov start (no export)t	421	1673	0.030*	0.018
		Proc. innov start(no export)t	421	1673	0.028*	0.015
Stage 2	Prod. innov starter (in t-s)	Export start (importer)	224	375	0.067*	0.038
	Proc. innov starter (in t-s)	Export start (importer)	290	369	0.041	0.035
Stage 3A	Export starters (import in t-s, no innovation)	Prod. innov start (importer)t	107	196	-0.088**	0.034
		Proc. innov start(importer)t	107	196	0.081*	0.052
Stage 3B	Export starters (import and innovate in t-s)	Add. future prod. innov	285	48	0.082*	0.043
		Add. future proc. innov	285	74	0.161***	0.044

Medium-sized firms (with between 50 and 200 employees)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Import status (not export or innov in t-s)	Export start (no innov)t	95	85	0.168*	0.092
		Prod. innov start (no export)t	95	95	0.054	0.058
		Proc. innov start(no export)t	95	95	0.008	0.043
Stage 2	Prod. innov starter (in t-s)	Export start (importer)	171	140	0.124**	0.049
	Proc. innov starter (in t-s)	Export start (importer)	205	96	-0.022	0.049
Stage 3A	Export starters (import in t-s, no innovation)	Prod. innov start (importer)t	61	32	0.158***	0.048
		Proc. innov start(importer)t	61	32	0.075	0.101
Stage 3B	Export starters (import and innovate in t-s)	Add. future prod. innov	163	14	0.002	0.094
		Add. future proc. innov	163	21	-0.281**	0.095

Large firms (with more than 200 employees)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Import status (not export or innov in t-s)	Export start (no innov)t	91	30	-0.222	0.173
		Prod. innov start (no export)t	91	31	-0.207	0.212
		Proc. innov start(no export)t	91	31	0.012	0.047
Stage 2	Prod. innov starter (in t-s)	Export start (importer)	460	163	0.110***	0.031
	Proc. innov starter (in t-s)	Export start (importer)	451	105	-0.068**	0.032
Stage 3A	Export starters (import in t-s, no innovation)	Prod. innov start (importer)t	63	39	-0.096	0.068
		Proc. innov start(importer)t	63	39	0.090	0.106
Stage 3B	Export starters (import and innovate in t-s)	Add. future prod. innov	319	15	0.127*	0.073
		Add. future proc. innov	319	18	-0.046	0.074

Note: Subsampling based standard errors (500 repetitions, subsample size is 80% of the total sample) whenever either the number of control or treated observations is less than 100.

Source: ESEE, own calculations

Table 7: Average treatment effects of nearest neighbor matching for manufacturing firms by size classes (Type 2: exports-innovation-imports)

Small firms (with at most 50 employees)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Export status (not import or innovate in t-s)	Import start (no innov)	408	1458	0.070***	0.017
		Prod. innov start (no import)t	408	1522	0.034*	0.019
		Proc. innov start(no import)t	408	1452	0.005	0.013
Stage 2	Prod. innov starter (in t-s)	Import start (exporter)	98	180	-0.030	0.045
	Proc. innov starter (in t-s)	Import start (exporter)	166	214	-0.002	0.038
Stage 3A	Import starters (export in t-s, no innovation)	Prod. innov start (exporter)t	202	217	0.088***	0.032
		Proc. innov start (exporter)t	202	231	0.142***	0.041
Stage 3B	Import starters (export and innovate in t-s)	Add. future prod. innov	526	11	0.155***	0.050
		Add. future proc. innov	526	16	-0.203	0.156

Medium-sized firms (with between 50 and 200 employees)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Export status (not import or innovate in t-s)	Import start (no innov)	86	86	0.189***	0.060
		Prod. innov start (no import)t	86	88	0.004	0.054
		Proc. innov start(no import)t	86	83	0.038	0.042
Stage 2	Prod. innov starter (in t-s)	Import start (exporter)	68	39	-0.062	0.079
	Proc. innov starter (in t-s)	Import start (exporter)	100	46	-0.257*	0.151
Stage 3A	Import starters (export in t-s, no innovation)	Prod. innov start (exporter)t	100	44	-0.033	0.054
		Proc. innov start (exporter)t	100	45	0.043	0.064
Stage 3B	Import starters (export and innovate in t-s)	Add. future prod. innov	226	6	0.089	0.107
		Add. future proc. innov	226	4	0.104	0.171

Large firms (with more than 200 employees)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Export status (not import or innovate in t-s)	Import start (no innov)	67	22	-0.107	0.148
		Prod. innov start (no import)t	153	118	-0.084	0.079
		Proc. innov start(no import)t	153	109	0.135***	0.040
Stage 2	Prod. innov starter (in t-s)	Import start (exporter)	110	48	0.661***	0.120
	Proc. innov starter (in t-s)	Import start (exporter)	166	50	0.196	0.254
Stage 3A	Import starters (export in t-s, no innovation)	Prod. innov start (exporter)t	236	50	-0.102	0.152
		Proc. innov start (exporter)t	236	50	0.114*	0.063
Stage 3B	Import starters (export and innovate in t-s)	Add. future prod. innov	442	9	-0.254	0.252
		Add. future proc. innov	442	8	0.153	0.134

Note: Subsampling based standard errors (500 repetitions, subsample size is 80% of the total sample) whenever either the number of control or treated observations is less than 100.

Source: ESEE, own calculations

Table 8: Average treatment effects of nearest neighbor matching for manufacturing firms by distance to technological frontier (Type 1: imports-innovation-exports)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Import status (not export or innov in t-s)	Export start (no innov)t	120	584	0.097***	0.032
		Prod. innov start (no export)t	120	635	0.016	0.030
		Proc. innov start(no export)t	120	635	-0.031	0.030
Stage 2	Prod. innov starter (in t-s)	Export start (importer)	60	54	0.043	0.086
	Proc. innov starter (in t-s)	Export start (importer)	79	56	-0.059	0.068
Stage 3A	Export starters (import in t-s, no innovation)	Prod. innov start (importer)t	31	22	-0.010	0.072
		Proc. innov start(importer)t	31	5	0.250**	0.090
Stage 3B	Export starters (import and innovate in t-s)	Add. future prod. innov	87	11	0.464***	0.117
		Add. future proc. innov	87	9	0.024	0.316

Productivity leaders (firms in the fifth quintile of value added per employee)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Import status (not export or innov in t-s)	Export start (no innov)t	94	77	0.186***	0.065
		Prod. innov start (no export)t	94	80	0.206***	0.068
		Proc. innov start(no export)t	94	80	0.091**	0.045
Stage 2	Prod. innov starter (in t-s)	Export start (importer)	261	147	0.101**	0.042
	Proc. innov starter (in t-s)	Export start (importer)	283	103	-0.054	0.042
Stage 3A	Export starters (import in t-s, no innovation)	Prod. innov start (importer)t	56	38	-0.014	0.070
		Proc. innov start(importer)t	56	38	-0.033	0.115
Stage 3B	Export starters (import and innovate in t-s)	Add. future prod. innov	197	20	-0.005	0.079
		Add. future proc. innov	197	24	0.013	0.183

Note: Subsampling based standard errors (500 repetitions, subsample size is 80% of the total sample) whenever either the number of control or treated observations is less than 100.

Source: ESEE, own calculations

Table 9: Average treatment effects of nearest neighbor matching for manufacturing firms by distance to technological frontier (Type 2: exports-innovation-imports)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Export status (not import or innovate in t-s)	Import start (no innov)	173	571	0.115***	0.026
		Prod. innov start (no import)t	173	595	0.029	0.025
		Proc. innov start(no import)t	173	580	0.010	0.020
Stage 2	Prod. innov starter (in t-s)	Import start (exporter)	27	33	-0.019	0.107
	Proc. innov starter (in t-s)	Import start (exporter)	42	43	-0.121	0.187
Stage 3A	Import starters (export in t-s, no innovation)	Prod. innov start (exporter)t	74	68	-0.095	0.063
		Proc. innov start (exporter)t	74	70	0.042	0.063
Stage 3B	Import starters (export and innovate in t-s)	Add. future prod. innov	185	4	0.022	0.061
		Add. future proc. innov	185	3	-0.067	0.178

Productivity leaders (firms in the fifth quintile of value added per employee)

	Treatment variable (in t-s)	Outcome variable (in t)	N treatm.	N control	ATT	s.e.
Stage 1	Export status (not import or innovate in t-s)	Import start (no innov)	57	54	0.088	0.083
		Prod. innov start (no import)t	57	50	0.250***	0.061
		Proc. innov start(no import)t	57	55	0.134	0.096
Stage 2	Prod. innov starter (in t-s)	Import start (exporter)	76	15	0.625**	0.269
	Proc. innov starter (in t-s)	Import start (exporter)	134	33	0.115**	0.052
Stage 3A	Import starters (export in t-s, no innovation)	Prod. innov start (exporter)t	136	31	0.187***	0.067
		Proc. innov start (exporter)t	136	38	0.125	0.086
Stage 3B	Import starters (export and innovate in t-s)	Add. future prod. innov	281	5	-0.125	0.345
		Add. future proc. innov	281	4	-0.343	0.355

Note: Subsampling based standard errors (500 repetitions, subsample size is 80% of the total sample) whenever either the number of control or treated observations is less than 100.

Source: ESEE, own calculations

Appendix

Econometric approach

The crucial element in our econometric approach is the choice of the relevant cohorts of firms and the subsequent analysis of their transition into different modes of transnational operation and innovative success. In order to determine the direction of causality, we undertake two parallel identification approaches denoted by Type 1 sequencing, where we focus on importing firms' likelihood of becoming first-time innovators and first-time exporters, and Type 2 sequencing, where exporting status is the starting point of the analysis and its impact on the likelihood of starting to innovate and starting to import is explored. We explore both possible directions of causality so as not to exclude possibly important causal relationships in the nexus of importing, exporting activity and (product and process) innovation.

Our identification strategy for **Type 1 sequencing** proceeds as follows

- We start with a cohort of importing firms (i.e. firms that have imported in period t,), but have neither exported nor innovated in either of the past three years ($t-2$, $t-1$, and t). As per (9) we specify a propensity to import function by using lagged firm characteristics such as labor productivity, size, capital intensity, foreign ownership and sectoral and time dummies) as determinants of the current importing status (an indicator variable taking on value 1 for currently importing firms that have neither exported or innovated in the past three years and 0 for firms that are currently not importing and have not exported or innovated in the past three years)
- We use the above propensity score estimates to test three possible scenarios:
  - Firstly, we are interested in whether current importing status has an impact on the likelihood of becoming a first-time exporter. We define first-time exporters as firms that will export in the next period ($t+1$) but have not exported before ($t-2$, $t-1$, and t) nor have they innovated ($t-2$, $t-1$, and t)[19]. Obviously, we do not restrict the possibility that these firms imported or are currently importers. Based on the import status propensity score we match importing with non-importing firms and estimate the average effect on the likelihood of becoming first-time exporters.
  - Secondly, we also explore the effect of importing status directly on innovation. Given that we dispose with data on either product or process innovation, we look at two separate scenarios with product-innovation starters and process-innovation starters. For the purpose of this analysis innovation starters (product or process[20]) are defined as firms that will innovate in period $t+1$, but have not innovated in any of the previous three periods ($t-2$, $t-1$, and t).In addition, we assume that while these firms may or may not be importers, they have not exported in any of the periods ($t-2$, $t-1$, t and $t+1$). Again, based on the propensity score (9) importers and non-importers are matched and the effect of importing status on the probability of starting to product/process innovate is estimated.
- The second phase of the identification strategy focusses on the effects of the newly acquired exporting/innovation status may have on starting to innovate/export respectively. We, again, focus on three scenarios.

[19] We tested the impact of importing status on the probability of starting to export separately from the probability of starting to innovate and explicitly assume that export starters do not simultaneously become first-time innovators and vice-versa. When we allow for those firms that have started exporting and innovating simultaneously our results remain qualitatively identical.

[20] Firms that started to product and process innovate simulaneously were treated both separately as well as by inclussion in either of the two innovation scenarios. Again, the results do not differ qualitatively from the ones presented.

- We explore the role that becoming a new exporter may have on the likelihood of becoming a first-time product or process innovator. In order to test for the effects that newly acquired exporting status may have on the probability of becoming a first-time innovator, we focus on the cohort of firms that started exporting in period t (i.e. did not export in either $t-1$ nor $t-2$) and have also been importers (at least from $t-1$ onwards). Logically, these cohort does not include firms that have innovated in either of the three periods. Based on this definition of firms, we estimate propensity to start exporting (11), where the probability of becoming an export starter is dependent on lagged labor productivity, capital intensity, size, foreign ownership and a full set of sector and year dummies. Based on this propensity score new exporters are matched with importing firms that did not start exporting in period t and have not exported before. Also, the control group of firms is assumed not to have innovated either in any of the periods so far. The matched pairs of firms are used to determine the possible effects of new exporting on the likelihood of becoming a product/process innovator. Where the latter cohort is defined as firms that product/process innovate for the first-time at $t+1$ and have imported at t (their exporting status however is allowed to be indeterminate).
- Analogously, we explore the likelihood that new innovators (either product or process or both) become first-time exporters. We start with the cohort of firms that have innovated for the first time in period t (separately for product and process innovators[21]), hence did not innovate in either $t-1$ nor $t-2$, but have been importers from at least $t-1$ onwards. All of the included firms did not engage in exports in either of the three periods in question ($t-2$, $t-1$, and t). Using this definition of innovation starters we estimate the respective propensity score functions (10) for product and process innovations, based on which we perform nearest neighbor matching of innovation starters with firms that were importers but have not started to innovate at time t. Lastly, the average treatment effect of having started to innovate on the probability of becoming a first-time exporter in period $t+1$[22] is estimated. Again, we assume that these newly ($t+1$) exporting firms were already importing and have also started to innovate at time t.

- The third and final phase of identification focuses on the cohort of new exporters that have started as importers and have also experienced some innovation success in the past. The aim of this segment is to see whether firms that have innovated in the past can experience a new wave of innovation activity brought about by the added dimension of international activity (becoming an exporter). We use the definition of export starters (that have been importers and have innovated) as given above, but define repeat innovators as firms that are currently not innovating (at time t) but have innovated either at time $t-1$ or $t-2$.Using the propensity score specification (11) for this cohort of export starters at time t, we match export starters with non-starters, that have also been importing and innovating in the past, to test whether having started to export will have any impact on the probability of additional innovation activity. The average treatment effects are estimated separately for product and process innovators[23].

The **Type 2 sequencing** identification algorithm proceeds analogously. Instead of reviewing the whole specification as above, we focus only on the differences in the two approaches.

[21] As before, we also consider the case that firms simultaneously started to product and process innovate, but, again, no qualitative differences emerged.

[22] Having not exported beforehand ($t-2$, $t-1$, or t).

[23] We also allow for switching between product and process innovation (e.g. firms that have product innovated in the past becoming process innovators and vice versa) and the results remain valid.

- the starting point for this scenario are currently exporting firms (t) that have neither imported nor innovated so far ($t-2$, $t-1$, and t), instead of the importers that were the base for type 1 scenario. As was the case with import status, export status is used as a treatment variable in order to explore it's effect on both the probability of becoming a first-time importer as well as the probability of becoming a new product or process innovator.

- the second stage again mirrors the one from the Type 1 scenario by focussing on the new importer and new (product or process) innovator status and estimating whether it impacts the probability of becoming a first-time (product or process) innovator and new importer, respectively. As was the case with the Type 1 sequencing identification strategy, we assume that these firms have been exporters by the time they started to innovate or import. For instance, the respective cohorts of interest are therefore firms that have begun innovating for the first time in period t and have been exporting since at least $t-1$. Comparing these firms with firms that did not begin to innovate in period t and have also exported since at least $t-1$, we estimate the impact of lagged innovation-starter status on current probability of becoming an import starter. Similarly lagged import starter-starter status is used to estimate the probability of becoming a first-time innovator.

- In the final stage, we take a closer look at repeat innovators and estimate whether having become an importer in addition to being an exporter impacted the probability of additional successful innovation. As before, we only consider firms that innovated in the past and are currently not innovating and look at whether having become first-time importers will have improved the likelihood of them becoming successful innovators once again.